

TABLE 4.

*The Relationship between the Amount of Water Present within the Container and Its Attractiveness as an Oviposition Site to the Females of A. scutellaris.*

Experiment Number.	Number of Replicates.	Water Container Surface.	Reflected Illuminance.	Number of Eggs Deposited.	Mean Percentage of Eggs Deposited.
8	8	Water Surface	100	7,583	54
		Moist Porous Surface	100	6,521	46

4. *The effect of both the reflectance and the texture of a water container surface upon its attractiveness as an oviposition site.*

The gravid mosquitoes were given two choices. The first was between a black, smooth surface, a grey, rough surface and a white, smooth surface. The second choice was between a black, smooth surface, a grey, smooth surface and a white, rough surface.

The attractiveness of water containers of unequal reflectance and varying textures was primarily determined by the texture of the surface, and the reflected illuminance became important only when it was so high that its unattractiveness masked any difference in the texture of the surface (experiments 9 and 10 of Table 5).

TABLE 5.

*The Relationship between the Reflectance and the Texture of the Water Container Surface upon Its Attractiveness as an Oviposition Site to the Females of A. scutellaris.*

Experiment Number.	Number of Replicates.	Water Container Surface.	Reflected Illuminance.	Number of Eggs Deposited.	Mean Percentage of Eggs Deposited.
9	7	Black Smooth	7	6,280	37
		Grey Rough	24	10,111	60
		White Smooth	100	410	3
10	5	Black Smooth	7	7,856	63
		Grey Smooth	30	4,622	31
		White Rough	100	386	6

5. *The effect of the reflectance and texture of the water container surface and the amount of moisture present within the container upon its attractiveness as an oviposition site.*

The gravid mosquitoes were given two choices between two water containers: the first between a Petri dish with a free water surface with a black background, and a Petri dish with a moist, smooth, grey, porous surface; the second choice was between a Petri dish with a free water surface with a black background, and a Petri dish with a moist, rough, grey, porous surface.

A water surface with a black background was preferred to a moist, grey, smooth, porous surface, and this preference was greater than that due to either the difference in reflectance (experiment 1 of Table 2) or the amount of moisture present (experiment 11 of Table 6). By altering only the texture of the grey, moist, porous surface from smooth to rough, however, this above preference for the water surface of low reflectance was completely reversed. Thus the moist, grey, rough, porous surface was decidedly more attractive to the ovipositing females than the free water surface (experiment 12 of Table 6).

TABLE 6.

The Relationship between the Reflectance and the Texture of the Water Container Surface and the Amount of Water within the Container upon Its Attractiveness as an Oviposition Site to the Females of *A. scutellaris*.

Experiment Number.	Number of Replicates.	Water Container Surface.	Reflected Illuminance.	Number of Eggs Deposited.	Mean Percentage of Eggs Deposited.
11	6	Water Surface with Black Background	7	6,522	88
		Moist Grey Smooth Porous Surface	24	1,298	17
12	5	Water Surface with Black Background	7	1,279	19
		Moist Grey Rough Porous Surface	30	5,445	81

The minimum number of replicates for the calculations of the means of each experiment was five, and the determinations of significance, although not strictly necessary because of the clear-cut preferences in all experiments, were made from determinations of standard deviation differences. Tables of students' "t" were used to read the probabilities, which in every case were less than 0.001.

#### DISCUSSION.

Because the larvae of *A. scutellaris*, a typical member of the subgenus *Stegomyia*, are always found in small accumulations of water, many of the factors of a larger aquatic environment, which may influence ovipositing females of other species, such as those found in swamps, rice fields and other similar large bodies of water, probably would not influence the females of this species when selecting a tree hole for oviposition. Therefore the behaviour pattern of oviposition by the females of *A. scutellaris* was thought to be guided more by the properties of the water container surface than by the properties of the water held in the container. That is, visual and tactile stimuli were thought to be more important than olfactory stimuli in guiding the selection of an oviposition site; for example, a typical breeding site of this species is a tree hole or a coconut husk, which has a rough texture, a moist, porous surface, a low reflected illuminance and usually only a small water surface.

On this assumption filter papers of different texture and varying reflected illuminances were used to form the water containers of the oviposition sites in the experimental cages, and the only precautions thought necessary for the prevention of any interaction of the variables introduced were: dyed filter papers only to be used in the same experiments; textural experiments to be repeated in constant darkness to eliminate possible visual stimulation; equal volumes of water to be maintained in the water containers to prevent unequal evaporation affecting the water vapour pressure gradients; and the sides of the Petri dishes to be taped with paper whose reflected illuminance matched that of the dish.

Although both Jobling (1935) and Muirhead-Thomson (1942) have investigated the influence of the environmental and the reflected illuminances upon the selection of an oviposition site by the gravid mosquitoes, little attention seems to have been given to reflected illuminances intermediate between high and low. In the present investigation the gravid mosquitoes of *A. scutellaris* were shown to have a preference for a breeding site which was approximately inversely proportional to its reflected illuminance. By studying the time of oviposition a relationship was shown to occur between the environmental illumination and the illuminance reflected from the oviposition site, for the bulk of the eggs of an egg batch was deposited upon surfaces of medium or low reflected illuminance during the hours of brightest illumination, that is about midday; however, the bulk of the eggs of an egg batch was deposited upon surfaces of high

reflected illuminance during the hours of lowest illumination, that is at dusk (see Figure 1). This relationship explained why a water container surface of high reflected illuminance was unattractive to ovipositing females.

The selection of an oviposition site by the grain weevils, *Rhizopertha dominica* and *Calandra granaria*, has been shown by Crombie (1941) and Eastham and McCully (1943) to depend mainly upon the texture of the grain surface. Similarly the gravid females of *A. scutellaris* were influenced in their selection of an oviposition site by the texture of its surface, and although this preference was not absolute, it was constant for all conditions under which it was studied (see experiments 5, 6 and 7 of Table 3).

When both the texture and the reflected illuminance of the oviposition site were studied, the preference for a rough textured surface of medium reflected illuminance over a smooth textured surface of low reflected illuminance (experiment 9 of Table 5) was the same as that for a rough texture over a smooth texture, both of equal reflected illuminance (experiment 5 of Table 3). However, a rough textured, surface with a high reflected illuminance was decidedly unattractive (experiment 10 of Table 5). From these preferences it was assumed that the gravid mosquitoes first selected an oviposition site because of its reflected illuminance, but once there the texture of its surface determined whether any eggs would be deposited or what proportion of the egg batch would be deposited. As the gravid female mosquitoes were found to deposit their eggs either *in toto* or over varying periods of days, both of these possibilities could occur.

The preference for a water surface over a moist, porous surface of equal reflected illuminance, although only slight, was decided and significant (experiment 8 of Table 4). But by combining the water surface with a low reflected illuminance this preference was increased until it was greater than that due to either the above preference for the water surface, or the preference for a surface of lower reflected illuminance (experiment 1 of Table 2). Thus it appeared that a summation of preferences occurred.

By altering the texture of the moist, porous surface from smooth to rough, and comparing its attractiveness with that of a water surface of lower reflected illuminance, the above preference for a water surface was completely reversed; that is, a moist, porous surface of rough texture and medium reflected illuminance was more attractive than a water surface of low reflected illuminance. It was therefore concluded that the combination of a rough texture with a moist surface made the water container so attractive to ovipositing females that all other preferences were ignored.

This investigation has therefore determined that the physical properties of a water container surface are of decided importance in guiding the selection of an oviposition site by a mosquito species which breeds in such water containers as tree holes. The sequence of events in this selection would appear to be an initial attraction to a water container due to its reflected illuminance, but once the texture of the surface and its moisture content were determined by the gravid mosquito, the decision of the attractiveness of such a site was made. From this it was concluded that a moist, porous surface of rough texture and low reflected illuminance so closely resembled the preferred oviposition site of the gravid females in nature that the selection of tree holes, coconut shells and other similar water containers was governed by these physical properties of the water container surface.

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NOTES ON THE MORPHOLOGY AND BIOLOGY OF *SCAPTIA VICINA* TAYL.  
AND A NEW SPECIES OF *SCAPTIA* (DIPTERA, TABANIDAE).

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(Thirty-four Text-figures.)

[Read 27th October, 1954.]

*Synopsis.*

Larvae of *Scaptia vicina* (Tayl.) were found at Roseville, N.S.W. The larva and pupa are described and figured. The type and paratypes of *S. muscula*, n. sp., were reared from larvae found, in association with the larvae of a species of Myrmeleontidae, in the sand deposits which occur beneath overhanging rocks in the sandstone areas near Sydney, N.S.W. Imago, larva and pupa are described and figured.

INTRODUCTION.

Very little work has been done on the immature stages of any of the Pangoniinae. The larva and pupa of the Nearctic *Goniops* have been described or mentioned by McAtee, Malloch and Stone, and also by Schwardt and Walton, but these two papers have not been seen by the writer. The immature stages of two Australian species have been described in more detail, *Scaptia auriflua* (Don.) by Fuller (1936) and *Ectenopsis vulpecula* var. *angusta* (Macq.) by English (1952). In the Tabanidae (Diptera) of Australia (Mackerras, to be published), eighty-two described species of Pangoniinae are listed from Australia, so it is apparent that a great deal remains to be discovered about their early stages.

Feeding was a problem in rearing the Tabanid larvae described here, as the soil was too dry for earthworms, which have been used successfully by other workers. Something had to be provided that did not mind dry soil, would not crawl up the side of the jar, would not decompose if left untouched or partly eaten, and would not retaliate when attacked. Muscoid pupae filled all these requirements, but were not readily taken by the larvae; various Lepidopterous pupae were accepted, but were not always to be found. Dr. D. F. Waterhouse, of the Division of Entomology, C.S.I.R.O., suggested *Ephestia*, and provided a culture, which has been maintained for two years and has proved most satisfactory.

*SCAPTIA VICINA* Taylor (Text-figures 1-14).

This species was described under the name *Erephopsis vicina* by Taylor (1918) from one specimen, a male, from Wentworth Falls, N.S.W. It was transferred to *Scaptia* by Ferguson (1926), within which it is being placed by Mackerras (paper to be published) in the *maculiventris* group of species. In the writer's collection are three adults taken in the field in N.S.W., one female at Avalon in Feb., 1948, one male taken at Woolwich in March, 1950, and a male taken at Roseville in March, 1953. It is also known from Barrington Tops and the Dorrigo plateau at elevations of 4,000-5,000 feet.

Two larvae were found at Roseville, at one end of an area of about an acre, surrounded by houses, where large trees had been left growing, and where at that time weeds and decaying vegetation covered the ground. They were found on a steep slope at the higher end of this area. One larva was found in August, 1952, when soil was being turned over with a hand trowel; later it pupated, and a female emerged in Feb., 1953. It was identified as *S. vicina* by Dr. I. M. Mackerras. The second larva was found in March, 1953, under a raked-up heap of decaying leaves and grass. During March and April it fed upon the Lepidopterous pupae supplied, but after that various pupae and larvae were left untouched, except for a Tipulid larva which was sucked out in August. In December the larva appeared to have decreased a little in size,

but this may have been caused by the soil in the jar becoming too dry and being left dry for some weeks. It pupated in January, and a female with one wing slightly deformed emerged in February. Eggs were not found.

*Larva* (Text-figs. 1-11).

The larva (Text-figs. 1-2) is large, stout, circular in cross-section, and, when fully extended, it tapers very much anteriorly to the small head and very slightly to the truncated posterior end. A full-grown larva, when extended, may be about 30 mm. long and about 9 mm. across the widest part. When touched or otherwise disturbed it will contract very much, and may then be about 17 mm. long and about 11 mm. wide, and it appears to be short, cylindrical, and truncated at both ends. Contraction is effected largely by the telescoping of the tapering anterior segments, with relatively little shortening of the posterior segments.

The integument is coarsely striated all over, except on the anterior collar of the prothorax, the small spiracular area, the anal tubercle, and very narrow areas between the segments. Beneath the striated integument is a layer containing a pale brown pigment in an irregular network pattern (Text-fig. 2). The pigment is much darker in the middle line of both dorsal and ventral surfaces in the posterior half of each segment, and the body colour is cream in the non-pigmented areas, so the living larva appears mottled, with a central, dark, longitudinal, broken, double line on the dorsal and ventral surfaces. Graber's organ cannot be seen in the living larva, owing to the pigment obscuring it. The pigment is not present in larval exuviae.

*Head.*—The head can be completely withdrawn, but the antennae, palps and tips of the mandibles project when the larva is extended at all. The mandibles are large and quite black, and the external openings of the mandibular canals can be seen under the binocular magnifier with magnification  $\times 10$ .

The antennae (Text-fig. 3) are large. The basal segment is about 1 mm. long, with a strong chitinous internal structure and a thick layer of integument, and it bears two small, pointed, sensory processes on one side near the distal end. The second segment is about 0.3 mm. long, with a chitinous internal structure similar to the first segment, and a very thin integument. The third segment is bifid, with both branches slender, tapering, pointed and about equal in length.

*Mouth-parts.*—The mandibles (Text-fig. 4) are large, almost square at the tip, with very slight serrations on the lower edge, and so heavily chitinized that the mandibular canal is not visible in a slide of the last larval exuviae mounted in balsam. The maxillae (Text-fig. 4) are of clear chitin, with a wide basal portion and a long narrow distal blade. The anterior edge of the base is armed with rows of long, slender, pointed hairs, and the proximal half of the lower edge of the blade is similarly armed. The maxillary palp is three-segmented; it has a short, thick, basal segment, a long cylindrical second segment, and a long, slender, pointed third segment, which is nearly half the length of the second segment.

The labrum (Text-fig. 5) is blade-like, about three times as long as high, mainly of clear chitin, with some dark longitudinal bands of heavier chitin. There are several pairs of sensory organs placed midway along the down-curved dorsal surface; further forward is a pair of strong setae; beyond these is a deep indentation; and the labrum ends in a narrow, upturned, distal portion bearing a pair of slender setae. On the latero-ventral surface is an extensive area covered with papillae and bordered dorsally with long-pointed hairs or bristles. The labium (Text-fig. 5) ends in a thick, fleshy, pointed, tongue-like structure covered with fine pointed hairs. It is attached to a heavily chitinized pharynx support, and salivary ducts run back from it to the large salivary pump. On its ventral surface is a pair of very small, forwardly directed labial palps set in an area covered with hairs.

Except for minor differences, and the fact that it is much larger and more heavily chitinized, the head capsule is very similar to that of *S. auriflua* (Don.) described by Fuller (1936) and to the new species described in this paper.

*Thorax* (Text-fig. 6).—The prothorax is encircled anteriorly with a wide collar, or annulus, which narrows abruptly for attachment to the head capsule. It is covered with more or less closely set scales, each armed on the posterior edge with backwardly directed spines. On the anterior half of this prothoracic annulus, each scale bears a few long, strong spines (Text-fig. 7); on its posterior half the scales are further apart, and each bears numerous fine spines (Text-fig. 8). There is a difference in colour in these two areas in the living larva, the anterior part being colourless and the posterior part mottled light brown. The whole annulus can be withdrawn.

Each thoracic segment bears two groups of at least four long, strong, chitinous setae on the ventral surface, one group on each side of the middle line. There are also some hairs on each segment. The prothorax bears at least 14 hairs, 4 large and 4 small on dorsal surface, 2 large on ventral, and 2 large on each lateral surface; the second and third segments each bear 6 hairs. There is no pubescent annulus on the anterior border of the second and third segments, but there are a few very small areas of brownish rough integument on each.

The openings of the anterior spiracles were not found.

*Abdomen*.—On segments 1-7 are very small paired, dorsal and ventral pseudopodia, and two lateral pseudopodia, one above the other, and behind each is a swelling, which extends longitudinally almost the length of the segment and is very noticeable when the larva is moving. Laterally on each segment are three long hairs visible with a magnification  $\times 20$ . Each segment also bears two small hairs on the dorsal surface and two minute hairs on the ventral surface, visible only in slide mounts at a magnification  $\times 60$ ; on segments 3-5 at least there are in addition two smaller hairs. There is an incomplete circlet of small areas of rough, brownish integument at the anterior border of segments 1-8.

The eighth segment (Text-figs. 9-10) is abruptly truncated, and there is no siphon. At the posterior end are two rounded dorsal tubercles, each with one long hair, on each side is an elongated tubercle bearing two long hairs, and between these is the flat spiracular area surrounding the posterior spiracle. The large anal tubercle, with unstriated rugose integument, is situated on the ventral posterior surface of the segment.

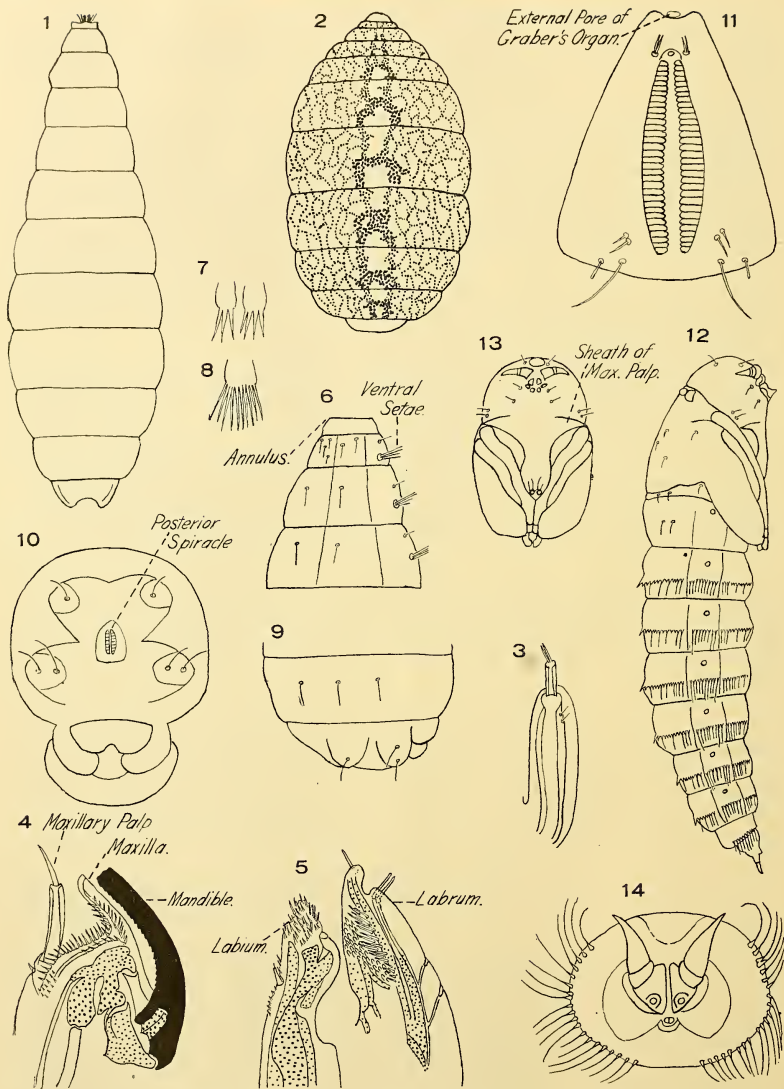
The posterior spiracle (Text-fig. 11) is of typical Tabanid form. It lies in a vertical slit in the spiracular area and protrudes very little, if at all. The spiracular area is roughly triangular in shape, with more or less vertical striations in the integument, and it bears several hairs. On each side, just above the spiracle, is a pair so close together that they look like one hair, while on each side below the spiracle are three pointed hairs, one long and two short, and also one hair with a rounded tip. The external opening of Graber's organ is at the apex of the area above the spiracle.

#### *Pupa* (Text-figs. 12-14).

The head and thorax in the living pupa are of pale brown chitin, except the spiracular tubercles which are dark brown; the chitin of the abdomen is very dark brown.

The larger of the two pupal exuviae measures 30 mm. long and about 7 mm. across the thorax. The head and thorax (Text-figs. 12-13) are armed with very fine, short setae, which may be seen with magnification  $\times 10$ ; they are placed directly on the chitinous surface and are not raised on mound or tubercle. On the head are one pair each of frontal and vertical setae, anterior and posterior orbital setae, and two pairs of lateral orbital setae. The antennae are short, and they rise from low, broad, antennal tubercles which almost meet in the centre line. Above is a low, broad, frontal tubercle, and below is the carinate tubercle; together these form a slightly raised, furrowed and ridged area. The sheath of the proboscis is very elongated (Text-fig. 13). It is produced well beyond the sheaths of the maxillary palps, and extends to the median junction of the sheaths of the first tibiae.

The *thorax* bears four pairs of very slender setae, a basal alar seta on each side, and three pairs of setae on the dorsum, the anterior, posterior and median mesonotal

Text-figures 1-14. *Scaptia vicina* (Taylor).

1-11, Larva.—1, partly extended, dorsal view,  $\times 3$  approx.; 2, showing pigment pattern,  $\times 3$  approx.; 3, antenna,  $\times 25$ , approx.; 4, mandible and maxilla,  $\times 25$  approx.; 5, labrum and labium,  $\times 25$  approx.; 6, thorax, lateral view,  $\times 5$  approx.; 7, scales with spines from anterior part of annulus,  $\times 250$  approx.; 8, scale with spines from posterior part of annulus,  $\times 250$  approx.; 9, 8th abdominal segment, lateral view,  $\times 5$  approx.; 10, 8th abdominal segment, end view,  $\times 10$  approx.; 11, posterior spiracle and spiracular area,  $\times 70$  approx.

12-14, Pupa.—12, lateral view,  $\times 3$  approx.; 13, head and thorax, ventral view,  $\times 3$  approx.; 14, 8th abdominal segment, end view,  $\times 8$  approx.